DISCRIMINATION OF CLANGS FOR DIFFERENT INTERVALS OF TIME.

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PART II.

I. EXPERIMENTS WITH DISTRACTION.

[NOTE. The writer feels that some explanation is necessary for the length of the "time interval" between the first and second parts of this investigation; it was due to the leaving of some of the data in California—only a part of which the writer has been able to obtain. There are several errors in the tables in the first article [*Amer. Jour. Psy.*, Vol. XI, No. 1]. P. 75, "total = 160" should read "total = 323," and in the line below "1440" should be 1603. On page 77 "total judgments for G" should be "2111" instead of 1211. This article is based on experimentation carried out by Mr. Henry Harwood, A. M.—the collaborator of the writer in Part I of this investigation, where can be found the general tables embodying the results of the experiment. Würzburg, July 8th.]

The experiments with distraction were undertaken partly with a view of testing the memory-image theory of comparison, and partly in the hope that by varying the form of distraction some insight might be obtained into the manner in which two sensations are bound up into a judgment. It was thought that, if the delivery of such a judgment depended on the carrying over of a memory image from the first impression to the second for the purpose of comparison, almost any strong form of distraction should decrease the percentage of right judgments, and that some forms should act with more disturbance than others either because they were more absorbing—that is, inhibited all memory images alike, or because the particular form in which they functioned interfered more strongly with the motor or sensory vehicle of the memory image.

Accordingly for the first group of reagents,—L., W., A., and S. (experiments of '95-'96), five kinds of distraction were used, viz.:

1° Continuous addition of written figures. (Ad.)
2° Counting metronome beats—3 per second. (M1.)
3° Counting metronome beats—1½ per second. (M2.)
4. Reading letters of printed words backwards. (Rdg.)
5. Reading interesting literature aloud (intoning). (Lit.)

As the counting of metronome beats seemed to become mechanical with practice, two other forms of distraction were

substituted with reagents G. and B. (experiments of '96-'97); they were:—

6° Listening to interesting reading. (H'r'g.)

7° Discriminating between pairs of clangs differing by 8, 4 or 0 vibrations. (D'c'n.)

As a comparison of two tones requires a period of at least 3 seconds, and again as it takes an appreciable time for interest to be aroused in listening to reading, these last 2 forms of distraction could not be used for the shorter intervals; they were accordingly applied only to intervals of 10, 20, 30, 40 and 60 seconds. On the other hand it is to be said that distraction for the one second interval can mean only that the 'set' of the reagent's mind is different from that for an unfilled interval.

Inasmuch as the several forms of distraction are applied to six different norms for the reagents G. and B., and to three different norms for reagents L., W., A., and S., it will first be necessary to consider the relation of pitch to the number of

TABLE V (a).

Percentages of right cases [r] of reagents L., W., A., S., for the norms 540, 560, 580, with differences [△] of 8, 4, 0 vibrations, with and without the Distractions Ad., Rd., Lt., M^1, M^2. Each percentage given is usually based on 72 judgments for norms 560 and 580, and on 36 judgments for norm 540. Nine (9) time intervals from 1 to 60 sec.*

Reagent.	Norm.	No.	D'n.		D'n.	No.	D'n.		D'n.	No.	D'n.		D'n.
		△	*r*		*r*	△	*r*		*r*	△	*r*		*r*
L.	560	8	94	Ad	96	4	81	Ad	83	0	42	Ad	25
	540	8	98	Rd	94	4	91	Rd	86	0	64	Rd	41
	580	8	91	Lt	87	4	85	Lt	91	0	41	Lt	8
	580	8	96	M^1	93	4	82	M^1	84	0	50	M^1	28
	560	8	92	M^2	98	4	78	M^2	88	0	53	M^2	11
W.	560	8	86	Ad	79	4	60	Ad	64	0	64	Ad	63
	540	8	96	Rd	94	4	84	Rd	72	0	72	Rd	61
	580	8	90	Lt	83	4	78	Lt	75	0	81	Lt	49
	580	8	91	M^1	91	4	74	M^1	66	0	69	M^1	37
	560	8	93	M^2	78	4	66	M^2	68	0	56	M^2	56
A.	560	8	89	Ad	83	4	71	Ad	71	0	72	Ad	60
	540	8	88	Rd	90	4	88	Rd	75	0	73	Rd	63
	580	8	86	Lt	88	4	72	Lt	71	0	78	Lt	65
	580	8	92	M^1	94	4	70	M^1	73	0	83	M^1	56
	560	8	96	M^2	95	4	81	M^2	72	0	70	M^2	42
S.	560	8	59	Ad	42	4	54	Ad	53	0	19	Ad	13
	540	8	64	Rd	73	4	60	Rd	61	0	25	Rd	25
	580	8	60	Lt	61	4	45	Lt	72	0	44	Lt	13
	580	8	57	M^1	66	4	55	M^1	53	0	33	M^1	22
	560	8	49	M^2	47	4	50	M^2	44	0	28	M^2	14

*In the case of A. the percentages are based on 60 to 72 judgments.

TABLE V (b)

Percentage of right cases (r) of reagents G. and B. for norms 540, 560, 576, 640, 660, 768, with differences (△) of 8 4, 0 vibrations with and without Distractions Ad., Rd., Lt., H'r'g, D'c'n. Nine time intervals, 1 to 60 seconds, unless otherwise specified.

Reagent.	Norm.	△	No. D'n.		D'n.		△	No. D'n.		D'n.		△	No. D'n.		D'n.		Kind of D'n.
			No. Cases.	%r	No. Cases.	%r		No. Cases.	%r	No. Cases.	%r		No. Cases.	%r	No. Cases.	%r	
G.	540	8	72	92	72	93	4	67	75	68	88	0	36	67	36	67	Ad.
	560	8	71	93	72	90	4	72	75	72	81	0	36	48	36	31	Rd.
	576	8	72	90	72	76	4	72	76	72	63	0	36	50	36	19	Lt.
	640	8	72	81	70	75	4	71	68	70	55	0	36	47	35	43	H'rg. *
	640	8	64	91	64	73	4	64	66	64	64	0	32	22	32	22	D'c'n.*
	660	8					4	80	79	80	59	0	20	40	20	35	D'c'n.*
	768	8					4	80	64	80	67	0	20	35	20	25	D'c'n.*
B.	540	8	68	93	66	87	4	67	85	68	79	0	36	78	35	66	Ad.
	560	8	72	83	68	84	4	72	93	72	84	0	36	81	36	66	Rd.
	576	8	72	83	70	83	4	72	79	72	67	0	36	75	32	56	Lt.
	640	8	72	76	70	80	4	70	59	67	58	0	35	43	29	34	H'r'g.*
	640	8	64	92	62	77	4	64	73	64	62	0	32	41	32	53	D'c'n.*
	660	8					4	80	77	80	77	0	19	42	20	40	D'c'n.*
	768	8					4	80	42	80	44	0	19	32	20	35	D'c'n.*

*Intervals of 10, 20, 30 40, 60 sec.

right and wrong judgments before proceeding with the discussion of the effects of distraction. Table V gives a summary for all time intervals of the percentage of right judgments for all norms, and for all forms of distraction with the three differences of vibration (8, 4, 0,) between norm and variable. Luft, as is well known, found that the absolute discriminative sensibility was about constant for the region which includes our norms.[1] Wolfe's results on the other hand indicate rather a decrease in the number of right judgments with the increase in height of tone,[2] whilst Meyer reports a fairly constant value for the region 200 to 600 vibrations and a lower value for 100 and 1,200 vibrations[3] with Stumpf as reagent.

Our results with the first set of reagents (Table V a) show more correct judgments for N = 540 than for N = 560 or 580, but in some cases less correct judgments for 560 than for 580. These norms, however, differ so little that for the first set of results the question of the relation of pitch to discriminative sensibility need not be taken into account.

For reagents G. and B., taking the extremes of norms used under similar conditions, the averages for differences of 8 and 4 vibrations (without D) are:—

Per cent. right cases for G. and B.

Norm.	$\Delta = \pm 8$	$\Delta = \pm 4$	Norm.	$\Delta = \pm 4$
540	92.5	80.0	640	66.5
576	86.5	77.5	768	53.0

The experiments with norms 640 and 768 are based on results with time intervals 10 to 60 seconds, and therefore are not strictly to be compared with the results from norms 540 and 576. The indications from these figures are in favor of a decrease in the absolute sensitiveness to difference with increase in pitch; but the mean variation of these averages, if they may bear the name, is too great to permit much reliance to be placed on the indications. We shall, therefore, proceed to the discussion of the distraction experiments without regard to any general law of variation of the liminal difference with pitch.

Of the seven (7) forms of distraction mentioned above, the 'intonation' of interesting literature, and the listening to reading were the most distracting in the sense of being the most

[1] Luft: Ueb. d. Unterschiedsempfindlichheit f. Tonhöhen. Phil. Stud., V, S. 529.

[2] Wolfe: Unt'g ü. d. Tongedächtniss. Phil. Stud., III, S. 561.

[3] Meyer: Ueb. d. Unt'dsemp'k't f. Tonhöhen. *Z. f. Psy.*, XVI, S. 357.

absorbing. Coming after the monotony of the longer intervals in which the attempt was made to hold the mind steadily on the norm, these occupations were accompanied by fairly strong feelings of relief and interest, so that it was found necessary to give a premonitory signal in order that the reagents might pull themselves together for the apprehension of the variable sound. This 'apperceptive signal' was used for intervals above 3 seconds both for experiments with and without distraction. It is hardly necessary to state that the intonation was for the purpose of testing the theory that an inaudible 'Mitsingen' was the vehicle for carrying over the image of the norm to the moment of comparison. This theory, as is remarked by the writers of the first part of this investigation, is highly improbable in view of the relatively small differences used. For the shorter intervals, there was but little chance to become interested in the matter read; but the attempt to comprehend the meaning of a sentence or part of a sentence in the short time interval was hardly less absorbing than 'plot-interest.'

For the reagents of the first group the reading backwards of printed letters and the continuous adding came next in absorbing interest: in the former process particularly, a danger-signal for flagging attention is given from the occasional attempt to read the letters in direct order or even to pronounce the words which the letters compose.

In each of the above 4 occupations the distraction was more continuous and absorbing than was the case with counting metronome beats, where the intervals between successive beats or a mechanical way of counting gave chances for a recall of the norm—the temptation to which was the more insistent because it was to be suppressed.

The distraction by means of comparisons of pairs of clangs was of course undertaken in the hope of applying a 'crux' to the memory-image theory as well as of getting some sort of an estimate of the amount of distraction. It was presumed that during the process of apprehending the sounds and perhaps in the moment of judgment the attention would be wholly occupied: if this were not the case, if the mind of the reagent was more or less occupied with the central sensation of the original norm, it was supposed that the effect would be seen in a diminished number of right distraction cases.

Considering now the total effect of all forms of distraction on each of the reagents, we get the results set down in Table VI.

The most obvious conclusion to be drawn from the following table is that distraction often failed to distract in the sense of diminishing the number of correct judgments: in fact, if distraction had any effect at all on accuracy of judgment for differences of 8 and 4 vibrations between norm and variable, we

TABLE VI.

Number of instances of increase, equality and decrease in percentages of right cases for all forms of distraction as compared with the percentages for undistracted intervals.

	No. of instances of increase in % of right cases with distraction.			No. of instances of equality in % of right cases with distraction.			No. of instances of decrease in % of right cases with distraction.		
$\Delta =$	± 8	± 4	0	± 8	± 4	0	± 8	± 4	0
Reagent L	2	4	0	0	0	0	3	1	5
" W	0	2	0	1	0	1	4	3	4
" A	3	1	0	0	1	0	2	3	5
" S	3	3	0	0	0	1	2	2	4
" G	1	2	0	0	0	1	4	3	4
" B	2	0	1	1	0	0	2	5	4
Total	11	12	1	2	1	3	17	17	26

could conclude that it increased the accuracy about ⅔ as often as it decreased it, and in a few instances had no effect.

Very different are the results or the accompaniments of distraction for $\Delta = 0$: only once do we find any instance where the distraction was accompanied by an increase in accuracy of judgment, while in 26 instances the accuracy was decreased. Here, as in the effects of the flight of time without distraction, the objectively like cases seem to differ indeed from the unlike this stimuli in their relation to the processes of judgment, and makes still more questionable the propriety of mixing the results of like and unlike stimuli together into general averages, in these so-called memory experiments.

The next questions that naturally arise are:

1° Is the excess of about ⅓ wrong judgments in the experiments with distraction for differences of 8 or 4 vibrations to be attributed to any particular forms of distraction?

2° Is there any correspondence between the reagents' estimate of the depth and absorbing power of a given distraction and an increase in wrong judgments? Tabulating the instances where D was accompanied by an increase or a decrease of right judgments, or where no change took place, we find for the several values of Δ and for the several kinds of D the following table.

An effect of distraction apparent in the following table is more noticeable in this: it is that distraction affected differences of 8 and 4 vibrations about equally; for 4 reagents with 5 forms of distraction a difference of 8 vibrations resulted in 8 instances of increase and 11 of decrease in the percentages of right judgments, and a difference of 4 in 9 instances of increase and 10 of decrease. For six reagents with the first 3 forms of distraction, the corresponding figures for $\Delta = 8$ and $\Delta = 4$

TABLE VII.

Increase (in.) decrease (de.) and equality (eq.) in percentage of right judgments in distraction comparisons.

	REAGENTS B. & G.									REAGENTS L. W. A. S.									TOTAL REAGENTS B. G. L. W. A. S.								
	± 8			± 4			0			± 8			± 4			0			± 8			± 4			0		
	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.	IN.	DE.	EQ.
Dist'n Ad.	1	1	0	1	1	0	0	2	0	1	3	0	2	1	1	0	4	0	2	4	0	3	2	1	0	6	0
" Rd.	1	1	0	1	1	0	0	2	0	2	2	0	1	3	0	0	3	1	3	3	0	2	4	0	0	5	1
" Lt.	0	1	1	0	2	0	0	2	0	2	2	0	2	2	0	0	4	0	2	3	1	2	4	0	0	6	0
" M 1.										2	1	1	2	2	0	0	4	0									
" M 2.										1	3	0	2	2	0	0	3	1									
" Hrg.	1	1	0	0	2	0	0	2	0																		
" Dcn 1.	0	2	0	0	2	0	1	0	1																		
" Dcn 2.				0	1	1	0	2	0																		
" Dcn 3.				2	0	1	1	1	0																		

alike, are an increase of 7 and a decrease of ten (10). These figures are not easily intelligible on the basis of a memory-image theory of comparison.

In answer to the first of the above questions, it cannot be said that the distracting powers of any of these forms of occupation was very much in excess of any other. The first series of experiments with the interpolated discrimination of pairs of tones (Dcn 1) gives, indeed, 4 instances of decrease and none of increase, but the last series (with a different norm) gives 3 of increase and 1 of decrease. And here it may be objected that counting the number of instances of increase or decrease is too rough a way to estimate the effects or accompaniments of distraction, and that the amount of effect as expressed in each percentage should be taken into account. But W., to take one of many examples, drops from .93 to .78 for a difference of 8 vibrations with the distraction M^2, but rises for the same distraction from 66 to 68 for a difference of 4 vibrations. The variations of the percentages are too great to permit any comparison of them in pairs; but by lumping all the results for all kinds of distraction and for all reagents together we get figures which, if they have no worth as absolute values, illustrate, in all probability, the general trend of the accompaniments of distraction. A further objection might be raised to the effect that a careful determination of the type to which each reagent belonged should have preceded the experimentation. It is a fault of the investigation that not enough attention was given to the observations of the reagents on the mental process in play during the intervals. On the other hand, there was the danger with comparatively new and very conscientious re-

agents, of stimulating introspection to an extent that would have prevented all regularity in judgment. However, the experiments were in part undertaken to determine what sensory or motor vehicle, if any, existed which carried over the memory image of the first sound to the moment of comparison with the second. To this end we used such a 'drag-net' form of distraction as intoning interesting reading to act at once on any form the memory image might take, together with special aim at the "Mitsingen." In contrast with this was the purely special form of discriminating between tones, which was, of course, designed to act on the acoustic or rather auditory form of memory image. Between the two, with no especial sensory or motor disturbances, lay one of the most efficacious forms of distraction—listening to interesting reading (Hrg).

The question as to the agreement between the subjective impression of the depth or absorbing power of a given abstraction and the decrease in the percentage of right judgments is also to be answered negatively. Beginning with the intonation of interesting reading as the most absorbing form of distraction, next in order came reading letters of words read backwards, and last and least the counting of metronome beats M^1 and M^2. As the discrimination of pairs of sounds affected only 2 reagents we shall consider them separately. Tabulating the results for the 4 reagents L., W., A., S., who were acted on by the above 5 forms of distraction, we find for $\Delta = \pm 8$ and ± 4 the following instances of increase (in.) or decrease (de.) in percentages of right cases as compared with intervals without distraction.

	Rd.	M_2	Ad	Lt.	M_1
in.	3	3	3	4	4
de.	5	5	4	4	3

There is very little indication here of any correspondence between the depth of absorption and decrease in accuracy of judging. The most absorbing form of D—reading with intonation (Lt), is accompanied more often with an increase in percentage of correct judgments than the least absorbing form, of counting metronome beats at the rate of 1.5 a second. No very great amount of significance can, however, be attached either to the relative or absolute values of these figures; it might happen that experiments with more reagents or more experiments with the same reagents would change the order of the series. But there is very little probability that, except by chance, the figures would ever show even an approximate correspondence between the amount of subversion of judgment and the subjective estimate of the depth of distraction.

As was remarked above, the $\Delta = 0$ comparisons show the effects of distraction much more strongly than the differences

8 and 4, and a more decided answer to the question in regard to the correspondence of depth of distraction and subversion of judgment might reasonably be looked for in these cases. The following table gives the increase (+) or decrease (−) of the distraction judgments for $\Delta = 0$ reckoned in per cents of the undistracted intervals.

TABLE VIII.

Decrease in percentages of correct judgments with distractions for each reagent in $\Delta = 0$ comparisons.

Reagents.	Differences in % for the several forms of distraction $\Delta = 0$.				
L.	M^2 −79	Lt −76	M^1 −44	Ad −40	Rd −36
W.	M^1 −47	Lt −40	Rd −15	Ad − 2	M^2 0
A.	M^2 −40	M^1 −33	Lt −17	Ad −15	Rd −14
S.	Lt −70	M^2 −50	M^1 −33	Ad −32	Rd 0
G.	Lt −62	Rd −35	Ad − 0	—	—
B.	Lt −25	Rd −19	Ad −15	—	—

We have here the somewhat unexpected result that the counting of metronome beats (M_1 and M_2) which is the least absorbing form of distraction, together with the intonation of interesting reading (Lt) which is the most absorbing, seem to have the strongest subverting effect on the judgments, whilst adding (Ad) and reading letters backwards (Rd) have the weakest.

From the memory image standpoint, it does not add to the intelligibility of the situation that M_1 had the strongest, and M_2 the weakest subverting effects on the judgments of W. A further consideration of these results will occupy us in the special discussion of the $\Delta = 0$ judgments; here we have simply to remark that in the cases where distraction seemed to have the strongest influence, there is no congruence between the degree of distraction and the subversion of judgment.

The experiments with discrimination of interpolated pairs of clangs as distraction were carried out with two reagents only—S. and B., but at a considerable length. Three (3) main norms 640, 660 and 768 were used, and three minor or distraction norms 620, 528 and 880, for which Δ also had the values ± 8, ± 4 and 0. To the 10, 20, 30, 40 and 60 second intervals were applied respectively 1, 2, 3, 4 and 6 pairs of distraction judgments; thus with the interval of 60 seconds, after the main norm came 6 pairs of successive clangs, each pair of which was to be compared in respect to pitch and the judgment noted. Then came the D or main variable clang which was to be compared with the first of the series. The general results of this experimentation have already been given in Table V; in Table IX we give the detailed results for each time interval.

TABLE IX.

No. of right, wrong, like, and doubtful judgments for norms 640, 660, 768, without and with distractions due to discriminating between pairs of sounds. For each time interval and for each reagent 40 judgments with and 40 judgments without distraction. Differences of main norm and comparison ± 4 vibrations.

	REAGENT G.								REAGENT B.							
	No D.				D.				No D.				D.			
	r	w	lll	o	r	w	lll	?	r	w	lll	?	r	w	lll	?
10 sec.	25	7	8	0	18	13	9	0	20	12	8	0	18	9	13	0
20 sec.	23	11	6	0	23	6	11	0	21	12	6	1	23	10	7	0
30 sec.	22	13	5	0	22	12	6	0	27	11	2	0	20	15	5	0
40 sec.	22	9	9	0	20	10	10	0	21	15	4	0	17	10	13	0
60 sec.	21	12	7	0	22	9	9	0	22	13	5	0	18	11	11	0
Totals,	113	52	35	0	105	50	45	0	111	63	25	1	96	55	49	0

Taking the 'r' cases exclusively we find that G. lost with distraction, for intervals of 10 and 40 seconds—held her own for 20 and 30; and gained for 60. B. loses for all r intervals except for 20 seconds. But if we take the decrease in wrong cases as our guide we find that G. loses twice with distraction and gains 3 times, whilst B. loses once and gains 4 times. If we distribute the 'like' judgments equally between the right and the wrong, we get about an equal number of right cases for each reagent with and without distraction. But it is doubtful if we have any right to make any such distribution in experiments of this kind. The assumption on which such a procedure rests is that the constant and variable errors are similar in kind and in distribution for the equal and unequal stimuli, an assumption, which, as has already been shown, is far from being correct for this form of comparison. Beside the disproportionate increase in wrong cases in passing from unequal to equal stimuli, there is to be added a contradictory tendency in the like judgments according as they are applied to equal or unequal stimuli. G., for example, shows a tendency to underestimate the second tone for objectively like cases, and to overestimate it when the norm and variable are unlike. In some of the preceding tables the likes and doubtful judgments have been distributed between the right and wrong cases, for the sake of comparison with similar tables in other investigations, but the writer feels that the warrant for applying the general procedure in the method of right and wrong cases to experiments of this kind has yet to be shown.

The results of the experiments with distraction reflect very fairly the different opinions of different psychologists in regard to the effects of attention during the time interval. Wolfe

inclines to the belief that the accuracy of comparison depends in great measure on the exertion of attention during the interval,[1] though he remarks cases where no trace of the first tone seems to be present for the attention to act on. Lehmann, on the other hand, found that his reagents could discriminate better between gray disks if they did not concentrate their attention on a memory image in the interval.[2] Hamlin finds that the application of attention to the first stimulus during the interval is more likely to distract than to fix the fading memory image.[3] Radoslawowv concludes that a distraction of of attention during the time interval actually increases the "sharpness" of memory for lines, and his explanation of this result is that by repeated reproductions of the norm the memory for it becomes 'blunted;' when, however, the mind is otherwise busied in the interval of comparison the original impression remains fresh, and its reproduction through the associative action of the second stimulus can take place with greater ease and accuarcy.[4] In view of this explanation it is not going too far to say that had Radoslawowv's results shown an increase of accuracy with attention directed to the memory image of the norm, the effect would have referred to the law of repetition. So plastic, to paraphrase Clifford, is psychological explanation when it has physiologic clay for its wheel. But with one form of distraction in particular, Radoslawowv found a marked decrease in accuracy, and this was where a line was exposed shortly before the variable and differing from it by a value not far from the liminal difference. The decrease in accuracy through the interpolation of this line, Radoslawowv refers partly to 'mistaken' comparisons of variable and distracting lines, and partly to a blotting out of the image of the norm. As this form of distraction is analogous to that used by us in our last series of experiments, it may not be out of place to examine Radoslawowv's work somewhat in detail. Using 2 reagents, a norm of 30 millimeters, distraction distances varying from 26 to 34 mm. and a minimal change of 0.5 mm., Radoslawowv found, *e. g.*, that the intervening line disturbed the comparison in the case of reagent Seyfert, so long as it differed from the norm by about 0.8 mm.—the value of the liminal difference for the reagent. It cannot, however, be said that the method of minimal changes was used by R. in a legitimate way, for the 'steps' of the variable were anything but minimal; in the case

[1] Phil. Stud. III, S. 559.
[2] Phil. Stud. V, S. 127.
[3] Alice J. Hamlin, Attention and Distraction, *Am. Jour. Psy.*, VIII, p. 53.
[4] Radoslawowv Hadji-Denkow, Unt'sg'n ü. d. Gedächtniss f. raümliche Distanzen des Gesichtsinnes. *Phil. Stud.* XV, S. 366.

of reagent Möbius (p. 400), for example, in 9 sets of experiments out of 18 the minimal change was 0.5 mm., the maximal difference was 0.5 mm., and the mean variation zero, which means that the reagent noticed a change with the very first step in half of the experiments, and that this step was noted as "minimal." In the case of the other reagent, in 34 sets of experiments (10 determinations of the liminal difference to an experiment) the variable was moved 4 steps in 3 sets, 3 steps in 16 sets, and 2 steps in 15 sets. This is hardly more than a travesty on the method of minimal changes. Granting that the method was carefully used, it is hard to see how the introduction of a single line between norm and variable could lead to anything but a series of comparisons somewhat after the method of mean gradation. The writer surmises that Radoslawowv would have had fewer cases of mistaken comparisons had he used pairs of lines for filling the time instead of the mediating single line. How this investigator distinguishes between cases of blotting out of the norm, and false comparison is not clear; the evidence for it, so far as we can see, is deduced from the figures and is not given by introspection.

The main conclusion to be drawn from the distraction experiments is that judgments of tone discriminations can take place, and in the majority of our experiments did take place, without conscious comparison between the present sensation and a memory-image of a past sensation. When, for example, a reagent, after a long time-interval filled with interesting reading, from which he had to be practically aroused by a sharp signal in order to prepare himself for the apprehension of the second tone, nevertheless delivered a judgment with a feeling of considerable security, it is idle to speak of 'memory images' or indeed of comparison in the ordinary meaning of the word. Or when a reagent, after having accurately discriminated six pairs of tones, decided with ease that a tone just given is like or unlike a tone 4 vibrations higher or lower sounded 60 seconds before, and is correct in these decisions 63 times in 100, it is evident that the ordinary theories of tone comparisons need readjustment.

No more is it explicable on the theory of memory comparison that there should not have been a great increase in doubtful judgments in passing from undistracted to distracted discrimination, or indeed in failures to judge at all, or that the several forms of distraction should not have shown a far greater difference in effect than was actually the case. Both introspection and the numerical results in our work point to the form of discrimination which we may term *free judgments* (as opposed to 'bound')—the kind commonly given in ordinary life when we speak of a heavy book or a tall man, etc. Martin and Müller have shown that such a form of judgment existed in their ex-

periments with weights;[1] this form of judgment they call 'absolute,' but we think the term 'free' is probably better for psychological purposes, being already in use for the phenomena of reproduction. This matter of free judgments we shall discuss later in connection with the consideration of the 'like' cases. Meanwhile, it may be worth while to examine more critically than has so far been the case, the value of the memory-image theory as an explanation of discriminative judgment.

2. Memory Image Theory of Discrimination.

What may be called an authoritative statement of the memory-image theory is to be found in A. Lehmann's second research on Recognition.[2] Noting in the comparison of two stimuli, the tendency to overestimate the second, he says: "In the act of comparison the second sensation is always compared with the memory image of the first, and inasmuch as the memory image must be fainter than the present sensation, the latter will be estimated proportionately stronger: *i. e.*, it will be overestimated. As the memory image sinks towards zero with the increase of time elapsing between the two sensations, the more pronounced will be the overestimation of the second sensation."

Lehmann found, however, that the theory was not strictly confirmed by his own experiments on memory for sounds—the sound image, after 6 seconds, for example, "having come back almost to its original strength,"[3] so he falls back on the hypothesis of periodic phases of the memory-image. The additional contradicting fact appearing in his experiments, of the frequent underestimation of the second stimulus, he makes no attempt to explain, and the details which he gives, both in the matter of results and of the conditions of experimentation, are too scanty to enable one to form a fair and intelligent criticism of the work. It does not appear, however, that he became aware of these fluctuating memory images through introspection, or that he made any attempt to show them directly; as in the case of Wolfe, their power seems to have been implicitly inferred —on the basis, probably, of the apparently self-evident proposition, that a judgment involving comparison must come from an act of comparison in which the things compared are present in consciousness.

When we come to extend the notion of a vanishing or fading memory image to other characteristics of sensation and especially to qualities of sensation, it is not clear what is meant by fading or changing, and indeed we find here a reflection of the

[1] Martin and Müller. Anal. d. Unt'demp'k't. S. 43.
[2] A. Lehmann: Krit. und experiment. Studien ü. d. Wiedererkennen. *Phil. Stud.* VII, S. 205.
[3] *Op. cit.*, S. 207.

contradictions in respect to the accuracy of sensory memory noticed in our first article. Thus, it has been deduced that the memory image of a light sensation may fade either towards black or towards white[1] or towards a mean or type.[2] In the matter of memory for colors the question becomes more complicated. Does fading or growing dim here imply a decrease in saturation or a drift towards an adjacent part of the spectrum? Does the memory image for red fade towards pink or cherry, or is it towards orange or purple?

Does the memory image of the first of two successive tones fade towards the high or low end of the tone series, or does it merely fade in intensity and so seem to drift towards low? Turning to Table X we find, for example, for the last reagents

TABLE X.

Distribution of 'like' (111), *'higher'* (h), *'lower'* (1), *and doubtful* (?) *judgments with and without Distraction for reagents George and Bullock.*

Vibrations.		G. No Distraction.				G. Distraction.						B. No Distraction.				B. Distraction.					
		111	h	1	?	111	h	1	%	%	D	111	h	1	?	111	h	1	?	%	%	D
	=	24	5	6	—	24	3	9	69	67		=	28	6	2	—	23	7	5	1	78	65	
540	h	2	63	9	3	6	56	6	84	82		h	17	56	2	—	11	42	9	—	75	68	
	1	15	3	43	1	1	5	76	70	93		1	4	2	53	1	5	5	61	1	89	85	
	=	17	7	12	—	11	13	12	47	31		=	29	1	6	—	24	8	4	—	81	67	
560	h	4	55	13	—	7	52	13	76	72		h	6	54	12	—	7	55	8	—	75	79	
	1	8	4	59	—	2	3	67	83	93		1	19	3	50	—	9	6	55	—	69	79	
	=	18	9	9	—	7	7	22	50	19			27	6	3		18	7	7	4	75	56	
576	h	5	49	18	—	5	42	25	68	58			3	57	11		9	46	14	3	80	66	
	1	4	3	65	—	5	14	53	90	74			5	12	56		13	8	49	2	77	69	
	=	17	6	13	—	15	5	14	47	44		=	15	7	13	1	10	11	7	8	43	39	
640	h	14	39	19	—	13	36	23	54	50		h	7	55	9	1	2	60	6	1	77	88	
	1	3	9	59	—	13	13	52	83	67		1	5	31	34	—	7	10	38	4	49	68	
	=	7	11	14	—	5	15	12	22	16		=	13	9	10		17	12	3	—	41	53	
640	h	5	45	14	—	9	47	8	70	73		h	1	55	8		5	53	6	—	86	83	
	1	9	6	49	—	8	22	34	77	53		1	6	10	47	1	11	24	26	1	74	43	
	=	8	7	5	—	7	6	7	40	35		=	8	5	6		8	9	3		42	40	
660	h	8	18	4	—	8	13	15	45	36		h	4	29	7		6	31	3		72	77	
	1	5	4	31	—	14	7	23	78	52		1	3	8	29		11	7	22		72	55	
	=	7	4	9		5	3	12	35	25		=											
768	h	5	18	17		10	17	13	45	43		h											
	1	7	6	27		7	5	28	68	70		1											

[1] Münsterberg: *Psy. Rev.*, p. 4.
[2] Leuba: *Am. Jour. Psy.*, Vol. V, p. 382.

B. and G. (without distraction) that:—

With reagent G.,

Norm–h was judged "lower" 104 times or 23% of 'h.'
Norm–l was judged "higher" 35 times or 8% of 'l.'
Norm–h was judged "like" 43 times.
Norm–l was judged "like" 57 times.

With reagent B.,

Norm–h was judged "lower" 49 times or 12% of 'h.'
Norm–l was judged "higher" 66 times or 17% of 'l.'
Norm–h was judged "like" 38 times.
Norm–l was judged "like" 42 times.

In each reagent, therefore, the memory image must have drifted in each direction; in the case of G. with a prevailing tendency towards the higher end of the tone series, and with B. towards the lower end,—both reagents being wholly unaware of these processes. Now the nature of tone stimuli is such that we cannot adopt the elastic explanation advanced by Münsterberg in explaining similar results with shades of gray, *i. e.*, that the memory image faded either way according to the positiveness of the impression—a light shade being more positive for some reagents, and a dark shade for others. For in the series of tones judged by these reagents, reaching from 540 to 768 vibrations, it can hardly be said that one tone was more 'positive' than another, nor in the series of tone sensations is there the analogue of the assimilative and dissimilative processes which makes possible such an explanation as Münsterberg's. But according to the memory-image theory the above figures would indicate:—

1° That the memory image for G. faded more strongly towards 'low,' and for B. more strongly towards 'high.'

2° That the memory image of G. acquired such an impetus in fading, so to speak, as carried it beyond the region of 'likeness' more often than merely up to this region.

3° That the memory image of G. had different and opposing tendencies of fading according as the variable was like or unlike the norm.

An obvious explanation of the above figures is that G. simply miscalls perceived differences; he perceives the difference 'norm-high' but calls it 'lower.' But, as against this, in cases where we should expect to find any such tendency most pronounced—*i. e.*, in perceived differences of objectively like cases, the tendency, so far as it exists at all, is rather in the other direction. A discussion of this question will occupy us later on.

It may be said, and has been said, that the memory image neither increases nor decreases in size or intensity, nor changes in quality, but simply becomes dim and indistinct. If any intelligible meaning is to be given to these words, the result of

this growth in dimness and indistinctness would not be a larger liminal difference for the method of minimal changes, or a greater number of wrong judgments for the method of right and wrong cases, but rather a greater mean variation in the former method, and an increase in doubtful cases in the latter, and in both methods an increase in failures to judge at all.

Our tables, however, show no such result; L. who is the most accurate and S. the least accurate in judging objective differences, have the smallest number of doubtful cases. With A., who used the 'doubtful' category more often than any other reagent, we find, indeed, that the maximum number of "doubtful" judgments is with the 60-second interval, but on the other hand the 3- and 5-second intervals together evoke more doubtful judgments (12) than 30 and 40 seconds taken together (9).

Perhaps the simplest conditions for discussing this question are to be found in the case of toneless sounds, such as are given by the sound-pendulum, or better the fall-phonometer used by Starke in his experiments on the measurement of sound intensities.[1] Starke bases his explanation of the different results obtained in the time order on the fading memory image. "If the judgment is given," he says, "immediately after the impression of the second stimulus, the latter will be perceived in its immediate intensity, whereas the first sound being merely in the field of consciousness, can be compared only as a memory image with the second. But inasmuch as the memory image of weaker intensity as compared with the immediate impression, the influence of the time order must show itself in the over-estimation of the second sound.[2]" Turning to Starke's tables we find an extraordinary difference in the figures of the two time orders. Starting with positive or negative supraliminal differences Starke pushed the variable along, step by step, through the region of like judgments until a liminal difference was noted. Taking an 'ascending' variable, where the variable, at first noticeably weaker than the norm, is increased till it is like the norm, we find for three norms in the middle of the series investigated, the following differences

Intensity of Norm (mm.)	Intensity of Variable appearing like Norm (mm.)			
	Reagent Lt.		Reagent Lz.	
	Time order N—Variable	Time order V—Norm.	Time order N—Variable	Time order V—Norm.
200	85	209	87	223
300	176	344	137	316
400	253	408	212	417

[1] Starke, Die Messung v. Schallstärken, Phil. Stud. III, S. 262.
[2] *Ibid.*, S. 290.

in time order.[1] From the above table we are to infer, therefore, that the memory image faded with such great rapidity in the time order norm-variable that the sound of a ball falling 200 mm. appeared no stronger after an interval of less than one second than that of the succeeding ball falling 85 mm., *i. e.*, the first sound must have lost about 57% of its original intensity. It further appears that when the time order variable-norm was used, the first sound faded comparatively slowly—so slowly that at the end of the time interval the variable 209 appeared like the norm 200; *i. e.*, the variable had 'faded' only to the extent of less than 5% of the norm. It might be said that in the second case the attention was directed more closely to the variable, *i. e.*, the first sound—than to the norm, and that therefore the former was held more strongly in the focus of consciousness. Martin and Müller have shown in experiments with 'hefted' weights, that a change in the direction of attention from the second to the first stimulus changes the tendency of judgments,[2] and it is not to be denied that some such influence may have been in play here, though it is not probable that the change of attention would have effected so great a difference as is indicated by the above figures. Starke himself gives no account of the attitude of his reagents in the two time orders, or indeed whether they were aware of the change in order, but in the figures which show the results of the descending gradations, *i. e.*, of the decreasing variable—we find conclusive evidence that the discrepancy in 'fading' in the two time orders is not due to a change in the direction of attention. From the same tables that gave the preceding figures, we take the results which Starke found by starting the variable somewhat louder than the norm, and then decreasing it till it appeared like the norm.

Intensity of Norm(mm.)	Intensity of Variable appearing like Norm (mm.)			
	REAGENT Lt.		REAGENT Lz.	
	Time order N—Variable	Time order V—Norm.	Time order N—Variable	Time order V—Norm.
200	169	394	160	387
300	279	578	256	582
400	374	747	352	744

In the case of reagent Lt. "like" for a norm of 200 was reached at a height of 169—indicating a comparatively small amount of fading. With the variable coming first, however, "like" for the same norm 200 is reached at a height of 394—

[1] *Ibid.*, S. 289.
[2] Martin and Müller: Analyse der Empfindlichkeit. S. 185–196.

a loss in intensity according to the hypothesis of 97% of the norm, so that in this case, if the attention was directed chiefly to the variable, it only served to accelerate its fading.

In strong contrast with Starke's results Kämpfe[1] found a very small time error for each of his two reagents. Moreover, whilst one reagent generally overestimated the second sound, the other underestimated it. Like Starke, Kämpfe worked with toneless sounds, though produced by the sound pendulum and not by the sound phonometer. Both investigations were carried out in the same room, and according to the memory image theory should have produced similar results. Kämpfe states the memory-image theory of the time error and suggests that the results, contradictory of the theory, may have been due to a strong fixation of the first sound.[2] He lays no weight on the explanation, however, but points out that the contradiction exists, and that the further discrepancy in his own judgments, where he passes from under to overestimation of the second stimuli, is not in disagreement with Fechner's experiments.[3] It was also found in the experiment on the method of mean gradations alluded to above (p. 61, note) that the two reagents showed contrary tendencies in estimating the position of the middle stimulus in the two time orders.

In the method of mean gradation or supraliminal differences, more perhaps than elsewhere, any theory of the comparison of impressions by means of the waxing or waning memory images becomes a tangle of absurdities. According to such a theory, in comparing three successive impressions, a, b, and c, we hold

NOTE. The explanation of the above discrepancies is to be found in a complication of factors which have themselves become subjects of psychological investigation, but which at the time these experiments were carried out [1883-1889] were hardly surmised. The influence of two of these factors, *i. e.*, the point of departure of the variable, and the size of the steps in a gradation method were subsequently pointed out by the writer, working under the same experimental conditions as obtained in Starke's research. [F. Angell. Ünt. ü. d. Schätzung von Schallintensitäten, etc. *Phil. Stud.* VIII, S. 446-448.] Starke's tables give the impression that the point of departure for the variable, and the size of the 'steps' were closely proportional to the value of each norm used—conditions which would result in about the same number of judgments for all values of the norm. The writer would not here be understood as implying that such a procedure would invalidate Starke's results either as regards Weber's law, or the proportionality of sound intensity and height of fall, but it is to be inferred that the liminal values obtained by Starke (8 to 9 % of norm), hold good only for the particular conditions under which the experiments were performed.

[1] Kämpfe: Beit. z. exp. Prüf. d. Meth. d. r. und f. Fälle. *Phil. Stud.* VIII, S. 562.
[2] *Ibid.*, S. 583.
[3] Fechner: *Psychophysik*, I, S. 90.

a and b first as memory images till c comes along, and then we compare the 'distance' a-b with b-c. In the first place there appears no reason why the memory-images of a and b should not coalesce; as they are supposed to exist simultaneously in the mind, they must coalesce. Supposing, however, they could be kept apart, we find that we have to compare the 'distance' a-b with b-c, when a-b is the distance between a remote and a near memory image, and b-c the distance between a near memory image and a present sensation.[1] But of all this complicated comparison of central and peripheral sensations, but little trace is to be found either by way of inference from the figures of the different time intervals, or directly from introspection. When three successive sounds, a, b, and c, are given at short intervals and b is judged 'nearer' a than c, the sound c seems in the moment of judgment no less a perception and no more a memory image than a—introspection usually failing to find any trace of imagery except perhaps a more or less disturbing visual scheme of the 'distances.'[2]

[1] *Op. cit.*, S. 463.

[2] The term 'distance' is, of course, a figurative way of expressing degree of likeness or similarity. If the sounds a, b, and c are given, a and b coming from stimuli which are much nearer together than b and c, then we 'judge' that b is more like a in respect to intensity than like c, or figuratively, that the 'distance' a-b is less than b-c. It is to be observed that such a judgment can be given directly and immediately, without training and without reflection, by any one, child or adult, who is capable of discriminating between the sounds and holding them in mind. When, however, b moves towards c the difficulty in delivering a judgment increases, until it becomes exceedingly hard to say whether b is nearer a or c, or equidistant from both. This is a difficulty which is inherent in all psychophysical measurements and is not to be overcome either by experience or by reflection.

But besides this direct and so to speak, natural way of comparing three successive stimuli, Julius Merkel, in order to explain the discrepancy between his results and my own, has attributed to the reagents of my experiments, a power of comparing the several impressions according to their ratios, and this comparison according to ratio [Verhältniss] plays a most unimportant part in general in his explanation of results obtained by the method of mean gradations. Now it is obvious that the reagents could have given themselves over to comparing the three stimuli according to the arithmetical mean, geometrical mean, the golden mean, or any other ratio which they could have held in mind; but if introspection has any value as evidence, they did not. They started out in a series of experiments with the judgment that b, *e. g.*, was more like a in respect to intensity than like c; this is a direct and primary relation of similarity, and has no more to do with a comparison of intensity ratios than has the judgment that peaches taste more like apricots than like plums. In other comparisons, b seemed more like c than like a, and in some cases the reagents could not say whether b was more like c or like a in respect to loudness or intensity. Sometimes, not often, they had the conviction that b resembled a in respect to intensity just as much as it resembled c, or figuratively, that b was midway between a and c. These are the plain

In Bentley's[1] work on the optical memory image, the image was voluntarily produced as far as possible after a signal given just before the variable was exposed—the purpose of the research being an investigation of the qualitative 'fidelity' of the voluntarily aroused central ideas. But even under these conditions it was found that 'free' judgments, *i. e.*, judgments in which introspection failed to find a trace of comparison with a memory image, were given quickly and with a feeling of considerable security. The memory image itself Bentley found more easily producible at the end of five minutes than of one minute.

In Radoslawowv's investigation on memory for lines we find a good example of the elasticity of the memory-image theory. In the earlier part of Radoslawowv's extended research he asserts, very emphatically, that it is impossible for the attention to be directed during the time interval to the memory image, as the image is rarely present, and when present, is indistinct.[2] But further on, as has been already remarked (p. 68), we find R. explaining the more accurate results obtained when the time intervals were filled with some distracting occupation, on the hypothesis

facts in the case, and if Merkel desires to call this way of comparing, a comparison by ratios, he is of course free to do so. But if by this he means that the reagents tried to compare the stimuli in such a way that a should be to b, as b to c, I am bound to say, first, that the reagents gave themselves over to no such artificial scheme, and secondly, had they done so the results could not have been regarded as valid any more than Merkel's own results with his method of double stimuli—and for the same reason,—they would have been the outcome of reflection and inference from experience. As regards Merkel's remarkable assertion that I found the geometrical mean of the stimuli because I had to find it (*Phil. Stud.* X, S. 212), I am free to say that beyond a slight weakness for the arithmetical mean because it is easier to calculate, I find in myself no marked tendency towards either mean—assuredly no such compulsive force as would have driven me for about 2 years through the not highly exhilarating exercise of dropping ivory balls on ebony plates in a hunt for a geometric mean. Why, if Merkel felt that from the first the work was predestined to the state of the geometric mean, he should have given so many pages to combating it, is not clear to me. Inasmuch as Merkel's objections are partly errors of comprehension, and mostly matters of small psychological moment, I have not thought that psychological research would be benefited by a detailed discussion of them. The main question at issue in the controversy is one of method, and to such psychologists as have the patience to wade their way through Merkel's investigations and my own, I am more than willing to leave the decision as to the way in which trustworthy results are more likely to be obtained—from a series of regularly graded stimuli which the experimenter presents to himself as reagent, or by an irregular series presented to reagents who have no knowledge either of the objective value of the stimuli, or of the trend of results.

[1] Bentley: The Memory Image and its Qualitative Fidelity, *Am. Jour. Psy.*, XI, p. 1.

[2] *Op. cit.*, S. 355.

that during the empty intervals the memory was 'dulled' by the incessant reproduction of the normal line, just as the memory image of a face fades the more, the longer the attention is directed to it.[4] On p. 396 again, we find that the inaccuracy resulting from introducing a distracting line between norm and variable is referred to the expunging of the memory-image of the norm by the intermediate line. In general, however, in these experiments of Radoslawowv, the writer is of the opinion that what has been investigated is not the 'sharpness' of memory for lines but rather the accuracy of comparison under circumstances of increasing difficulty, *i. e.*, increased intervals of time. For in the table which give the results of R.'s experiments with the method of minimal changes, we find that two of the three reagents (F. and E.) showed an increase in liminal difference values for the upper limina, for an increase in time interval, but failed to show any corresponding increase in the mean variation; in both cases the mean variation indicated small and irregular fluctuations. We are able to form no intelligible theory of comparison through an act of memory which would explain such figures; waxing or waning, fading or brightening of the first impression would all have given different results from the above. But similar results could have been obtained had the reagents compared simultaneously lines placed at increasing distances from one another. In such a case the liminal differences would have increased with the increase in distances between the lines exposed; and had the reagents waited till they felt the same degree of security for each liminal difference, the result would have a small and irregular fluctuation in the mean variation. They might, however, have recorded their first more or less insecure impression of a liminal difference; in this case the liminal value would not show much growth, but the mean variation would increase with the difficulty in comparison. This condition actually obtains in the lower liminal values for the two reagents F. and E. The writer regards this only as a possible explanation of these contradictory results; but the conventional scheme of memory comparison is here impossible. Experimenting on himself and using the method of right and wrong cases, Radoslawowv found in general a decrease in right judgments along with increase in time interval; for the time intervals running from 1 sec. to 13 sec. the decrease in right judgments was 65.3 to 46.3%.[1] For the same range of time intervals, *i. e.*, 1 to 15 seconds, Wreschner, using an irregular method of minimal changes, found little or no falling off in sensitiveness to differences for linear distances.[2] So far as such results concern the conventional scheme of sensory memory

[1] *Ibid.*, S. 366.
[2] *Op. cit.*, S.339.
[3] Wreschner: Meth. Beit. z. psychophys. Messungen, S. 231.

they are, of course, contradictory, but so far as they indicate the varying influences of different psychophysical methods they are in themselves interesting subjects for psychological investigation.

The writer has gone at some length into the memory-image theory of comparison because he considers that it has had an exceedingly harmful influence on psychological research. As Külpe says:[1] "It is remarkable that this theory should have maintained itself up to the present time, whilst the contradiction in which it involves the facts of experience, as well as any consistent explanation of these facts, have rarely been noticed." It was unfortunately launched with all the impetus that comes from Fechner's authority, though Fechner seemed well aware of its contradictions, and it still continues to glide along over logical inconsistencies and psychological absurdities. Its powers of adaptation are shown in Wreschner's argument against Külpe that although we are not aware of the presence of the memory image of the earlier impression in an act of comparison, "still the first impression can be regarded as artificially held in remembrance and passing over into the second, when it undergoes a change which can be regarded as the source of the time error.[2]" If it be objected that in this article, the fading or waning of the memory image has been interpreted in too much of a physical sense, it is to be replied, that this is precisely the trouble with the theory—it is a concept derived from physical processes with physical implications on which have been grafted the determinations of the psychophysical measurements, the outcome of which has been barren of all results for psychology.

An example of what an elastic memory-image theory with physical implications can accomplish is to be seen in Warren and Shaw's "Memory for square size[3]" in which we find not only a fading memory image, but a play of imagination images taking place according to the laws of chance, and under the dominating influence of Weber's law—which process goes on until the 'average imagination image' usurps the function of the memory image and brings about an overestimation of the norm. But of all this complication of waxing and waning, of fading and brightening of memory images, introspection has found but scanty trace, and when as in the case of optical stimuli the memory image occasionally appears, it has yet to be shown that it increases the accuracy of comparison in so-called memory experiments any more than the possession of an absolute memory for pitch increases discriminative sensibility for tones.[4]

[1] Külpe: Phil. Monatsh., XXX, S. 282.
[2] *Op. cit.*, S. 173.
[3] Psy. Rev. II, p. 241–243.
[4] Vid. v. Kries, Ueb. d. absolut. Gehör, Z. f. Psy. III, S. 262.